PATENT SPECIFICATION

DRAWINGS ATTACHED

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COMPLETE SPECIFICATION

Device for Colour Synthesis

We, IMPERIAL CHEMICAL INDUSTRIES LIMITED of Imperial Chemical House, Millbank, London, S.W.1, a British Company, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement: —

This invention relates to a novel device for synthesising, and to a method of colouring a substrate to match a given coloured pattern involving the use of such a device.

The compilation of sets of coloured elements for reference purposes is well known. Such compilations take the form of shade cards, colour atlases and the like and provide means whereby a particular colour may be characterised. The coloured elements contained in such compilations have hitherto been individually produced by the application to elements of paper, textiles or other suitable substrates of suitable colourants, for example by the dyeing or printing of such elements with appropriate dyestuffs or pigments or mixtures of dyestuffs or pigments. The number of such coloured elements which are included in any particular compilation naturally depends upon the range of colours which it is desired to characterise and also on the degree of variation in colour characteristics from one element to another which is required. Colour atlases have been produced which purport to embrace the entire range of possible colours, but in practice such atlases do not contain more than some 1,000—1,500 individual coloured elements and in consequence characterise only that number of different colours. To increase the number of coloured elements appreciably beyond this range raises very considerable practical problems.

The device of the present invention offers a means of synthesising and characterising colours whereby the number of different colours obtained is greatly in excess of the number of coloured elements provided.

According to the present invention there is provided a device for the synthesis of colours which comprises (a) a plurality of opaque coloured elements displaying the three subtractive primary colours in steps of increasing colour strength and binary combinations of those primary colours also in steps of increasing colour strength, and (b) a plurality of transparent elements displaying a neutral grey colour in steps of increasing colour strength, the opaque coloured elements being arranged in groups, the or each group being mounted upon backing material and any selected transparent element being superimposable at will upon any selected opaque element so that the said opaque element can be viewed through the said transparent element.

In synthesising colours by means of the device of the invention, the superimposition of each of the transparent elements in turn upon each of the opaque elements gives rise to a different colour.

The opaque coloured elements incorporated in the device of the invention may be produced by any of the known methods which have been referred to above, such as dyeing or printing. It is preferred, however, to produce the opaque elements by the procedure described in Specification No. 1,115,279, that is to say by the photographic printing on to an appropriately prepared substrate (dye-

[*Price 4s. 6d.*]

transfer paper) of three subtractive primary colours singly or in pairs by means of the dye-transfer process.

The proportions of colour strength in which the primary colours are combined will vary from one opaque coloured element to another, and the actual magnitude of those proportions will be determined by the total range of strength of each colour which it is desired that the set of opaque coloured elements should embrace and also by the increments of strength within that range which are to be represented. In order that the device should be capable of synthesising as large a number of different colours as possible, it is preferred that each primary colour in the opaque elements should be combined in strengths ranging from zero strength to full strength. In such a case it will be understood that the set of opaque elements will include elements displaying white only, elements displaying a single primary colour and elements displaying combinations of two primary colours selected from the three primary colours. In selecting the increments of strength within the desired strength range in which each primary colour is to be displayed, whether alone or in combination with another primary colour, it is found to be preferable, in order to facilitate the subsequent use of the colour-synthesising device, if the magnitude of the increments is such that the variation in strength of any particular primary colour throughout the set of opaque elements appears to the eye to be evenly graded. When the opaque elements are produced by the preferred method described in Specification No. 1,115,279, using the dye-transfer process, it is a straightforward matter to arrange for each of the subtractive primary colours to be transferred on to the dye-transfer paper in a predetermined number of steps ranging from zero strength to full strength such that, when pairs of the primary colours are transferred in all combinations of these steps, the desired total number of coloured elements exhibiting visually equal steps of each colour is produced. When using the dye-transfer process, the number of such steps may conveniently be in the range of 10 to 20; 15 such steps are preferred.

In producing the opaque elements, whether by the above-mentioned preferred method or otherwise, any such element displaying a binary combination of primary colours may be produced either by using a mixture of two separate colourants each of which furnishes a single primary colour, or by using a single colourant furnishing the required binary combination.

The transparent elements incorporated in the device of the invention may according to one method be produced by dye-transfer printing on to dye-transfer film of the three subtractive primary colours in combination in equivalent proportions, so as to give rise to the neutral grey; the three primary colours may either be printed individually in superimposition on to each film element, or they may alternatively be printed together from a single dyebath. A preferred method of producing the transparent neutral grey elements consists, however, in producing developed silver images in ordinary photographic film, the length of exposure given to each film element determining the optical density of the developed image which is obtained. The strengths in which the neutral grey colour is displayed by the transparent elements preferably extend over a range commencing at zero strength, and the number of the transparent elements may conveniently be in the range 10 to 30. Preferably there are 20 transparent elements exhibiting approximately equal visual steps of colour strength. Such a group of transparent grey elements may conveniently be produced in the form of a step wedge. The transparent elements are preferably of a similar size and shape to the opaque elements. The groups of opaque elements preferably display related colour combinations. The transparent elements are preferably held within a suitable form of supporting frame. For the sake of convenience where it is desired to synthesise a colour to match a particular coloured pattern, it is preferred that the means whereby the elements are superimposed should incorporate some method of permitting only the one selected opaque element to be exposed to view at a time, the other opaque elements meanwhile being masked.

Colours which are synthesised by means of the device of the invention may readily be characterised by allocating suitable reference characters to the opaque elements and the transparent elements respectively. Any colour synthesised may then be characterised by giving the references of the particular opaque element and the particular transparent element from which it is obtained.

By way of example, a description will now be given of a colour atlas embodying the invention, with reference to the drawings accompanying the provisional specification in which:

Fig. 1 is a diagrammatic representation in plan of one page of the atlas, more specifically the page consisting of coloured elements which display combinations of cyan and yellow primary colours;

Fig. 2 is a view in perspective of the mask and holder for the transparent grey step wedge, showing the step wedge in position;

Fig. 3 is a cross-section through the mask and holder along the line A—A in Fig. 2.

The atlas consists essentially of three components:

(i) three pages on which the opaque coloured elements are mounted;

(ii) a set of transparent neutral grey elements in the form of a step wedge pro-

duced in a length of photographic film;

(iii) a holder for the step wedge which permits any one selected opaque element on a page to be viewed through any element of the step wedge and which simultaneously performs the function of masking off the opaque elements on that page which are in the immediate vicinity of the opaque element selected.

Each page of the atlas (Fig. 1) consists of a sheet of dye-transfer paper 1, attached to suitable black backing material 2 which exhibits a group of opaque elements 3 displaying the various combinations of two subtractive primary colours; that is to say, the first group, on one page, displays the combinations of cyan with yellow, the second group, on a separate page, displays the combinations of magenta with cyan, and the third group, again on a separate page, displays the combinations of magenta with yellow. Each primary colour is printed on to the page by the dye-transfer process in a series of 15 bands, extending across the page, each band differing from its neighbours by visually equal steps; the band nearest one edge of the page displays the unchanged white colour of the paper, while the furthest band displays the primary colour at full strength. The two primary colours appearing on each page are printed mutually at right angles, so that each completed printed page consists of a group of 225 related coloured elements.

It will thus be seen that on each page of the atlas, one corner element will display white, the two adjacent corner elements will display one or other of the primary colours at full strength and the diagonally opposite corner element will display a combination of the two primary colours both at full strength. The remaining elements on each page will display various combinations of colours intermediate between the extremes displayed by these corner elements. For the purpose of characterising the colours, that are synthesised by means of the atlas, the coloured bands on each page are given location reference characters. For example, on the cyan/yellow page, the cyan bands are marked C0—C15 and the yellow bands are marked Y0—Y15, the numeral increasing with the strength of the colour displayed; the bands on the other pages are given similar appropriate markings. Any particular opaque coloured element in the atlas may then be identified by a combination of two such references, e.g. Y5 C11.

The transparent neutral grey step wedge (Fig. 2) consists of a series of 20 gray elements 4 which are developed silver images produced on a single strip of photographic film 5, together with one clear element having no silver image. Each of these elements differs in strength from its neighbours in such a way as to display approximately equal visual steps when viewed in superimposition upon an opaque element.

The transparent elements are designated by reference characters D1—D20 in increasing order of optical density. Reference character D0 designates zero density, that is to say complete absence of the film strip; the transparent element D1 itself has an optical density of about 0.05, so that the increment of optical density between D0 and D1 is equal to the increments between the other successive steps of the wedge.

The holder for the transparent step wedge, which also performs the function of masking off all the opaque coloured elements except the particular one selected, consists (Figs. 2 and 3) of a sheet of black card 6 equal in size to the pages bearing the opaque elements. At the centre of this card a second, smaller piece of black card 7 is attached through spacing members 8 in such a manner that a narrow gap 9 separates the faces of the two cards; registering apertures 10 and 11 of a size slightly greater than that of an opaque or transparent element are cut centrally in the cards 6 and 7 respectively. The length of film 5 constituting the step wedge is then passed through the gap between the two pieces of card, in which position it may be moved manually in either direction so as to bring each neutral grey element in turn in coincidence with the apertures. The whole assembly of holder and mask is placed over a selected page of the atlas so that the desired opaque element is also in coincidence with the apertures; the location of the coordinate corresponding to the selected page of opaque elements is facilitated by dotted lines 12 ruled in white on the face of the mask.

An alternative form of mask and holder for the grey elements is shown in the accompanying drawings in which:—

Fig. 4 is a diagrammatic representation in plan of the mask and holder;

Fig. 5 is a cross-section through the mask and holder along the line B—B in Fig. 4.

The holder consists of two parts; the first part is a sheet of black card 13 equal in size to the pages bearing the opaque elements, and the second part is a circular sheet of black card 14 which is rotatably mounted upon the first part at the centre thereof by means of a suitable pivot 15. The circular sheet 14 is provided with a number of peripheral tabs 16 whereby it may easily be rotated relative to the sheet 13, and possesses a concentric, elongated window 17 in which there are mounted in increasing order of optical density a series of transparent grey elements 18 produced on photographic film. As in the case of the elements of the step wedge illustrated in Figs. 2 and 3, each of the grey elements 18 differs from its neighbours by approximately equal increments (of 0.05) of optical

density, and the elements are again designated by reference characters D1—D20 in increasing order of optical density. An additional space designated D0 is provided in which the photographic film is absent. The masking sheet 13 has an aperture 19 of a size approximately the same as that of the opaque elements of the atlas, which enables any selected opaque element to be viewed through any selected transparent element. The location of the co-ordinates corresponding to the selected opaque element is in this case facilitated by the arrows marked on the face of the mask.

In place of manual operation, a suitable mechanical device may be employed to move either the step wedge illustrated in Figs. 2 and 3 or the circular sheet 14 illustrated in Figs. 4 and 5.

It will be seen that each of the 3×256 opaque coloured elements contained in the atlas may be combined with any of the 21 transparent elements (including absence of the film); the atlas is thus capable of synthesising and characterising some 16,000 different colours.

The combination of a particular opaque coloured element with a particular transparent element, as effected by means of the device of the invention constitutes a unique definition of the colour synthesised by that combination. The device may accordingly readily be employed in a mathematical procedure whereby a colour matching that of a given coloured pattern or sample may be obtained. In such a procedure, colorimetric reference coordinates are assigned to the combination; these reference coordinates may conveniently be, according to one known method of colour match prediction, the tristimulus values for the combination in question. These coordinates or values are transmitted to an appropriately programmed computer, together with additional necessary information concerning the substrate which is to be coloured to match the pattern provided, the dyes or pigments to be used and the colouration process to be employed; these data are converted in known manner by the computer into a dyeing or pigmenting recipe which, when applied to the substrate under the specified conditions, will give a colour matching that of the pattern.

Thus according to a further feature of the present invention there is provided a method of colouring a substrate to match a given coloured pattern, which comprises the steps of (a) synthesising by means of the device as claimed in any one of claims 1 to 15 a colour matching that of the said pattern, (b) assigning colorimetric reference coordinates to the combination of the selected opaque coloured element and the selected transparent element wherewith the required colour is synthesised, (c) transmitting these coordinates together with other necessary data concerning the substrate, the dyes or pigments to be used and the colouration process to be employed to computer means which is programmed so as to convert this information into a colouring recipe, (d) preparing a colouring composition in accordance with the said recipe and (e) applying the said composition to the substrate using the said process.

The first step required in carrying out the method is the operation of selecting from the device or atlas the page or group of opaque elements which contains an element lying most closely in shade to the pattern or sample provided.

Having selected the appropriate page of the atlas, the mask and grey wedge are moved over the group of opaque elements on that page until the combination of opaque elements and transparent element synthesising the required match is found. The correct combination of elements may be selected quite rapidly after a little practice in using the atlas has been acquired.

The second step consists in reading off the reference characters relating to the selected opaque element and transparent element and then converting these into the appropriate colorimetric coordinates for transmission to the computer. The tristimulus values for the selected combination may if desired be determined directly by performing the necessary measurements on the combination with a tristimulus colorimetric or spectrophotometer at the time the values are required. It is, however, much more convenient and less time-consuming if the values for all the possible combinations of opaque and transparent elements have been determined beforehand and have been compiled into a table which gives a direct correlation between the reference characters for the elements in a particular combination and the tristimulus values for that combination. Such information may also be stored as a library of data in a computer memory store. The compilation of such a correlation by measuring individually each possible combination of opaque and transparent elements with a colorimeter is, of course, a task of considerable magnitude. The manner of construction of the device of the invention is such as to permit a simple method of arriving at a satisfactory correlation without resort to such a task. This method consists essentially in the measurement of the spectral reflection of each of a selected small number of opaque elements covering the gamut of binary combinations, for example six opaque elements selected from each page of the atlas, the spectral reflectance for each such selected opaque element being measured both alone and in combination with each one of the transparent grey elements. A linear relationship, defined by a pair of constants for each wavelength, is found to exist between the reflectance of the opaque elements

alone and the corresponding reflectance of the opaque elements combined with a particular transparent element. A series of such pairs of constants may be used to calculate the reflectance curve for any of the approximately 16,000 combinations which the atlas may display, and a correlation in terms of tristimulus values may then easily be established.

WHAT WE CLAIM IS:—

1. A device for the synthesis of colours which comprises (a) a plurality of opaque coloured elements displaying the three subtractive primary colours in steps of increasing colour strength and binary combinations of those primary colours also in steps of increasing colour strength, and (b) a plurality of transparent elements displaying a neutral grey colour in steps of increasing colour strength, the opaque coloured elements being arranged in groups, the or each group being mounted upon backing material and any selected transparent element being superimposable at will upon any selected opaque element so that the said opaque element can be viewed through the said transparent element.

2. A device as claimed in claim 1, wherein the opaque elements are produced by a photographic dye-transfer process.

3. A device as claimed in claim 2, wherein each subtractive primary colour is displayed in the opaque elements in from 10 to 20 steps of colour strength ranging from zero strength to full strength such that the opaque elements exhibit visually equal steps of colour strength.

4. A device as claimed in claim 2, wherein each subtractive primary colour is displayed in 15 steps of colour strength.

5. A device as claimed in any one of claims 1 to 4, wherein the neutral grey colour is displayed in the transparent elements in from 10 to 30 steps of increasing colour strength commencing at zero strength.

6. A device as claimed in claim 5, wherein the neutral grey colour is displayed in 20 steps of colour strength such that the transparent elements exhibit approximately equal visual steps.

7. A device as claimed in claim 6, wherein the steps of colour strength differ from each other by approximately equal increments of 0.05 of optical density.

8. A device as claimed in any one of claims 1 to 7, wherein the transparent neutral grey elements are obtained by producing developed silver images of the required optical density in a photographic film.

9. A device as claimed in claim 8, wherein the transparent elements are produced in the form of a step wedge.

10. A device as claimed in any one of claims 1 to 9, wherein the groups of opaque elements display related colour combinations.

11. A device as claimed in any one of claims 1 to 10, wherein the transparent elements are held within a supporting frame.

12. A device as claimed in any one of claims 1 to 11, wherein means are provided for enabling the selected transparent element to be superimposed upon the selected opaque element and permitting the opaque element to be viewed through the transparent element whilst the remaining opaque elements are obscured from view.

13. A device as claimed in any one of claims 1 to 12, wherein the opaque elements and the transparent elements are individually designated and identified by reference coordinates whereby a colour synthesised by the combination of a particular opaque element with a particular transparent element may be characterised.

14. A device according to claim 1 substantially as hereinbefore described, with reference to the drawings accompanying the provisional specification.

15. A device according to claim 1 substantially as hereinbefore described, with reference to the accompanying drawings.

16. A method of colouring a substrate to match a given coloured pattern, which comprises the steps of (a) synthesising by means of the device as claimed in any one of claims 1 to 15 a colour matching that of the said pattern, (b) assigning colorimetric reference coordinates to the combination of the selected opaque coloured element and the selected transparent element wherewith the required colour is synthesised, (c) transmitting these coordinates together with other necessary data concerning the substrate, the dyes or pigments to be used and the colouration process to be employed to computer means which is programmed so as to convert this information into a colouring recipe, (d) preparing a colouring composition in accordance with the said recipe and (e) applying the said composition to the substrate using the said process.

17. A method as claimed in claim 16, wherein the colorimetric reference coordinates are the tristimulus values for the combination of opaque and transparent elements.

18. A substrate coloured to match a given coloured pattern, whenever obtained by a method as claimed in claim 16.

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Agent for the Applicants.

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1160673 PROVISIONAL SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

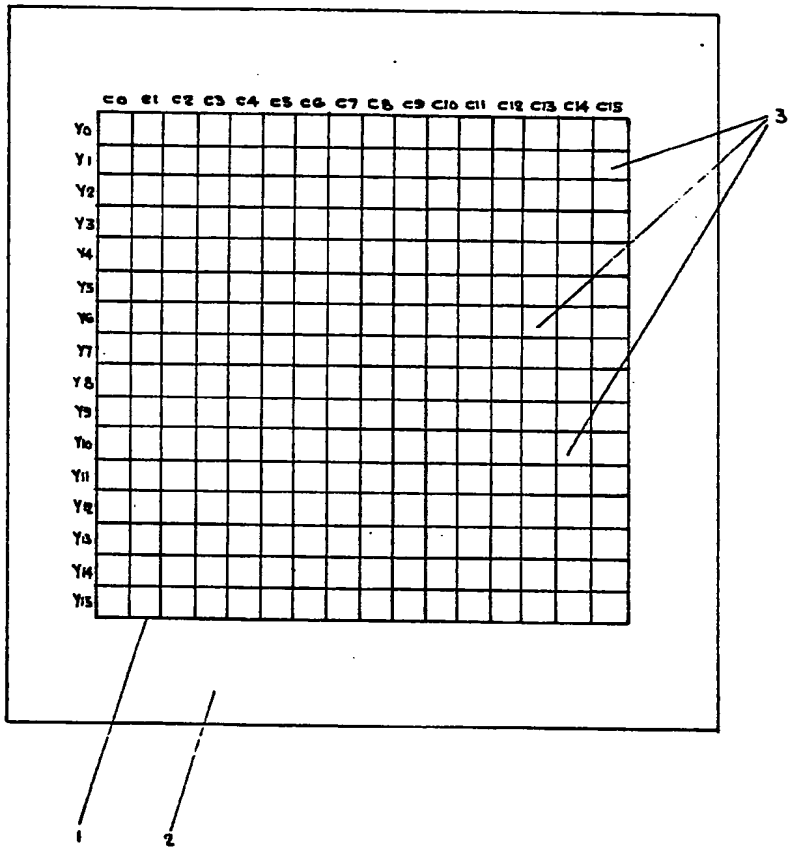

FIG 1

1160673 PROVISIONAL SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 2

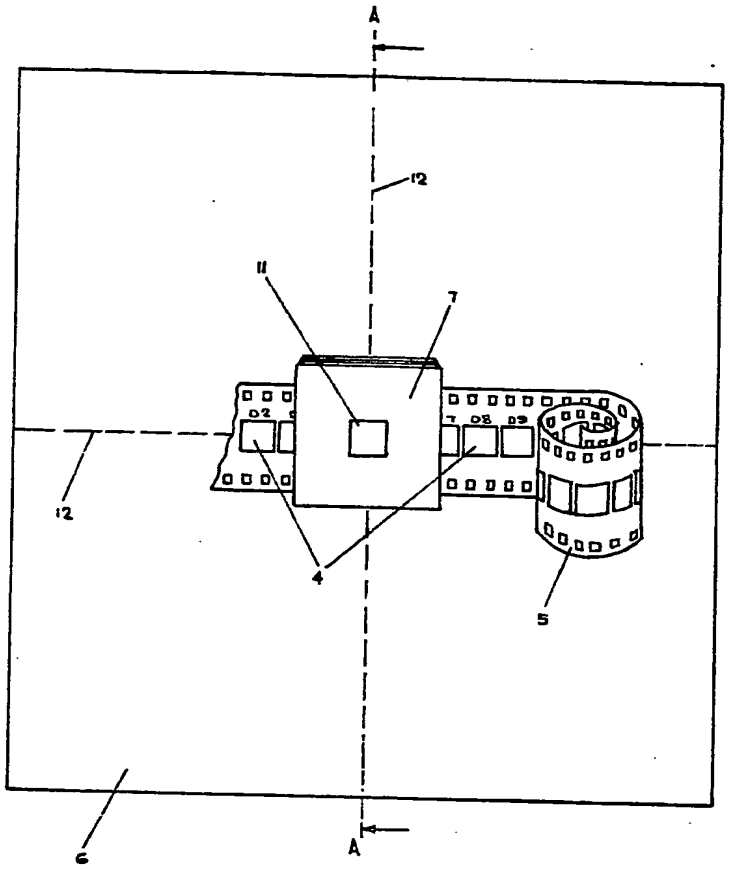

FIG 2

1160673 PROVISIONAL SPECIFICATION
3 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 3

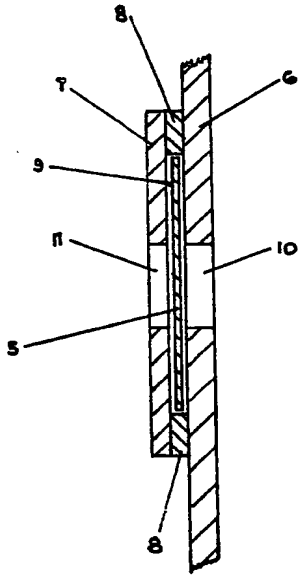

FIG 3

1160673 COMPLETE SPECIFICATION
2 SHEETS *This drawing is a reproduction of the Original on a reduced scale*
Sheet 1

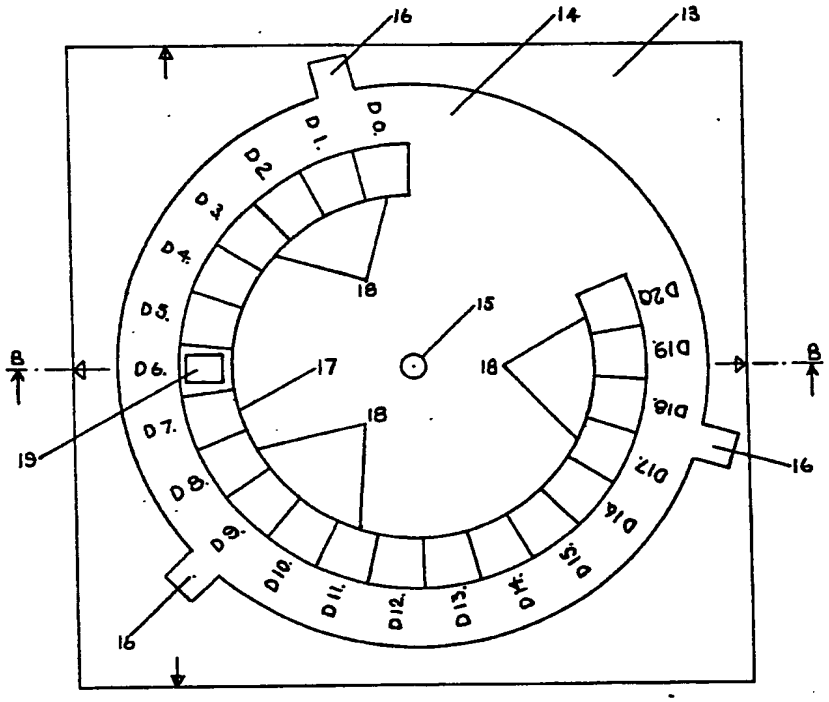

FIG. 4.

1160673 COMPLETE SPECIFICATION
2 SHEETS This drawing is a reproduction of the Original on a reduced scale
Sheet 2

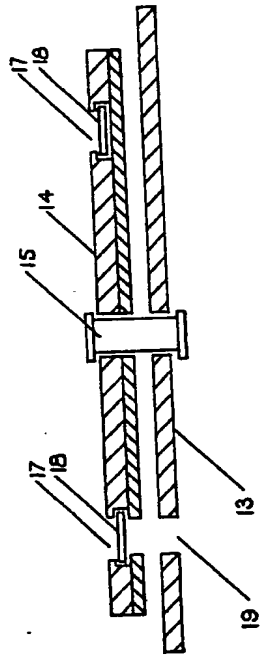

FIG. 5.